

Delirium Quantum¹

Or, where I will take quantum mechanics if it will let me

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Abstract. Once again, I take advantage of the wonderfully liberal and tolerant mood Andrei Khrennikov sets at his yearly conferences by submitting a nonstandard paper for the proceedings. This pseudo-paper consists of excerpts drawn from two of my samizdats [*Quantum States: What the Hell Are They?* and *Darwinism All the Way Down (and Probabilism All the Way Back Up)*] that I think best summarize what I am aiming for on the broadest scale with my quantum foundations program. Section 1 tries to draw a picture of a physical world whose essence is “Darwinism all the way down.” Section 2 outlines how quantum theory should be viewed in light of that, i.e., as being an expression of probabilism (in Bruno de Finetti or Richard Jeffrey’s sense) all the way back up. Section 3 describes how the idea of “identical” quantum measurement outcomes, though sounding atomistic in character, nonetheless meshes well with a William Jamesian style “radical pluralism.” Sections 4 and 5 further detail how quantum theory should not be viewed so much as a “theory of the world,” but rather as a theory of decision-making for agents *immersed* within a quantum world—that is, a world in continual creation. Finally, Sections 6 and 7 attempt to sketch once again the *very positive* sense in which quantum theory is incomplete, but still just as complete as it can be. In total, I hope these heady speculations convey some of the excitement and potential I see for the malleable world quantum mechanics hints of.

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1. TO H. M. WISEMAN, 24 JUNE 2002, “THE WORLD IS UNDER CONSTRUCTION”

Wisemanism 1 : *Do you believe that events in the world really are random? Or do you believe they only appear to be random? In the first case, doesn’t that mean that you have to believe in objective probabilities? . . .*

Or are you saying that the real world is unanalysable, unthinkable even? Everything we say should be couched in terms of gambling commitments. First, that seems to be a cop-out, giving up on any understanding of the Universe. Second, it can’t explain anything in the Darwinian way you mentioned, except Dutch-book consistency. It can’t explain why it is “bad” to hold a gambling commitment based on the idea that all world cup soccer balls contain bombs that have a 50% chance to blow up every time a goal is scored . . . You cannot say anything about animals that would have been likely to have gone extinct because of poor (but consistent) gambling commitments, because that is a statement using the concept of objective probabilities. You cannot explain anything that is not strictly deterministic without using objective probabilities, it seems to me.

I trust you understand my motives. I wouldn’t bother discussing this with you if I didn’t think your ideas were potentially revelational. What does not kill you makes you stronger.

Of the three options you gave me for answering your questions, I suppose if I were forced to choose one, I would align myself with the one you called a “cop-out.” However, from my point of view, the language you use builds about the ugliest picture it can for where this effort is going. Indeed, you miss the very point, the very beauty, of the “cop-out.” So, what I’d like to do is set that right—right here and right now—before we go much further.

You see, the very starting point for most of my latest thoughts—the thing I think quantum mechanics gives us the deepest and most thorough hint of—is that there is no such thing as THE universe in any completed and waiting-to-be-discovered sense. The thought I am *testing out* is that the universe as a whole is still under construction. And when I say this, I am not thinking of just bits and pieces of it; I am thinking of the whole shebang, all the way to the

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roots. Nothing is completed. Not just the playhouse Kiki is building for Emma and Katie, or the evolutionary track of the human species, but even the “very laws” of physics. The idea is that they too are building up in precisely the way—and ever in the same danger of falling down as—individual organic species. That is to say, it’s Darwinism all the way down.

So when you ask me if I am “saying that the real world is unanalysable, unthinkable even,” the answer in a way is “yes.” For it is blatantly impossible to analyze to the last detail the characteristics of a world that has not even been dreamt up (even in its own mind’s eye).

But how can I impress this upon you, or even make it seem reasonable as a direction for research? That is a tough call. For, like with beer or single-malt Scotch, it is surely an acquired taste that builds only slowly and with the right company. Of course, I could just send you back to my paper quant-ph/0204146, “The Anti-Växjö Interpretation of Quantum Mechanics,” [1] and ask you to take it very seriously. But this morning it dawned on me to maybe spend a little time with my scanner to try to “IV” some thoughts straight into your bloodstream.

At the moment, I can think of no better introductions to the line of thought I’d like to expose you to than three articles by Richard Rorty: “A World without Substances or Essences,” “Truth without Correspondence to Reality,” and “Thomas Kuhn, Rocks, and the Laws of Physics.”¹ (Read them in that order, if you read them.) All three papers can be found in his collection of essays, *Philosophy and Social Hope* [2]. If you absorb these, I think you’ll understand completely what I’m up to, and why I so dislike the negative connotations you associate with the radical-Bayesian way of viewing the quantum state. Of course, it may not turn your head the way it turns mine, but at least you’ll know where I’m coming from, and from what pool of enthusiasm I derive my strength to eschew the “golden nuggets” of *mere* quantum cosmology, *mere* Bohmianism, and *mere* “dreams of a final theory.” The world as I see it is a much bigger place than those stories can tell. And the interpretational issues at the core of quantum mechanics strike me as our first rigorous indication that there is something more to this idea than simply the hopes and desires of an enthusiast.

For now, let me give you a flavor of the thoughts in these papers, and then leave you on your own in the case that you would like to pursue this further. The following quotes come from “Truth without Correspondence to Reality.”

In this essay I shall focus on Whitman’s phrase ‘counts ... for her justification and success ... almost entirely upon the future’. As I see it, the link between Whitmanesque Americanism and pragmatist philosophy—both classical and ‘neo-’—is a willingness to refer all questions of ultimate justification to the future, to the substance of things hoped for. If there is anything distinctive about pragmatism it is that it substitutes the notion of a better human future for the notions of ‘reality’, ‘reason’ and ‘nature’. One may say of pragmatism what Novalis said of Romanticism, that it is ‘the apotheosis of the future’.

As I read Dewey, what he somewhat awkwardly called ‘a new metaphysic of man’s relation to nature’, was a generalization of the moral of Darwinian biology. The only justification of a mutation, biological or cultural, is its contribution to the existence of a more complex and interesting species somewhere in the future. Justification is always justification from the point of view of the survivors, the victors; there is no point of view more exalted than theirs to assume. This is the truth in the ideas that might make right and that justice is the interest of the stronger. But these ideas are misleading when they are construed metaphysically, as an assertion that the present status quo, or the victorious side in some current war, stand in some privileged relation to the way things really are. So ‘metaphysic’ was an unfortunate word to use in describing this generalized Darwinism which is democracy. For that word is associated with an attempt to replace appearance by reality.

Pragmatists—both classical and ‘neo-’—do not believe that there is a way things really are. So they want to replace the appearance-reality distinction by that between descriptions of the world and of ourselves which are less useful and those which are more useful. When the question ‘useful for what?’ is pressed, they have nothing to say except ‘useful to create a better future’. When they are asked, ‘Better by what criterion?’, they have no detailed answer, any more than the first mammals could specify in what respects

¹WARNING: Just because I say I can think of no better introductions to these ideas, it does not mean I endorse every statement in these papers; I may not endorse half of them. However, I think these papers go in the right direction, even if they go too far ... and even if their arguments are far too weak. But I choose the papers I do because they are easy reading, with beautiful writing, and I suspect these thoughts are so foreign to you that if you can find any sense in *some of them*, then it may be a good start for a dialogue. Moreover, I continue to stress that the best justification yet to pursue this direction of thought—and this is something Rorty does not know—is quantum mechanics itself. So, rather than being the final words on things, these are just the beginning words on things.

they were better than the dying dinosaurs. Pragmatists can only say something as vague as: Better in the sense of containing more of what we consider good and less of what we consider bad. When asked, 'And what exactly do you consider good?', pragmatists can only say, with Whitman, 'variety and freedom', or, with Dewey, 'growth'. 'Growth itself,' Dewey said, 'is the only moral end.'

They are limited to such fuzzy and unhelpful answers because what they hope is not that the future will conform to a plan, will fulfil an immanent teleology, but rather that the future will astonish and exhilarate. Just as fans of the avant garde go to art galleries wanting to be astonished rather than hoping to have any particular expectation fulfilled, so the finite and anthropomorphic deity celebrated by James, and later by A. N. Whitehead and Charles Hartshorne, hopes to be surprised and delighted by the latest product of evolution, both biological and cultural. Asking for pragmatism's blueprint of the future is like asking Whitman to sketch what lies at the end of that illimitable democratic vista. The vista, not the endpoint, matters.

So if Whitman and Dewey have anything interesting in common, it is their principled and deliberate fuzziness. For principled fuzziness is the American way of doing what Heidegger called 'getting beyond metaphysics'. As Heidegger uses it, 'metaphysics' is the search for something clear and distinct, something fully present. That means something that does not trail off into an indefinite future . . .

and

So far I have been trying to give an overview of Dewey's place in the intellectual scheme of things by saying something about his relation to Emerson, Whitman, Kant, Hegel and Marx. Now I want to become a bit more technical, and to offer an interpretation of the most famous pragmatist doctrine—the pragmatist theory of truth. I want to show how this doctrine fits into a more general programme: that of replacing Greek and Kantian dualisms between permanent structure and transitory content with the distinction between the past and the future. I shall try to show how the things which James and Dewey said about truth were a way of replacing the task of justifying past custom and tradition by reference to unchanging structure with the task of replacing an unsatisfactory present with a more satisfactory future, thus replacing certainty with hope. This replacement would, they thought, amount to Americanizing philosophy. For they agreed with Whitman that America is the country which counts for its 'reason and justification' upon the future, and *only* upon the future.

Truth is what is supposed to distinguish knowledge from well-grounded opinion—from justified belief. But if the true is, as James said, 'the name of whatever proves itself to be good in the way of belief, and good, too, for definite, assignable, reasons', then it is not clear in what respects a true belief is supposed to differ from one which is merely justified. So pragmatists are often said to confuse truth, which is absolute and eternal, with justification, which is transitory because relative to an audience.

Pragmatists have responded to this criticism in two principal ways. Some, like Peirce, James and Putnam, have said that we can retain an absolute sense of 'true' by identifying it with 'justification in the ideal situation'—the situation which Peirce called 'the end of inquiry'. Others, like Dewey (and, I have argued, Davidson), have suggested that there is little to be said about truth, and that philosophers should explicitly and self-consciously *confine* themselves to justification, to what Dewey called 'warranted assertibility'.

I prefer the latter strategy. Despite the efforts of Putnam and Habermas to clarify the notion of 'ideal epistemic situation', that notion seems to me no more useful than that of 'correspondence to reality', or any of the other notions which philosophers have used to provide an interesting gloss on the word 'true'. Furthermore, I think that any 'absoluteness' which is supposedly ensured by appeal to such notions is equally well ensured if, with Davidson, we insist that human belief cannot swing free of the nonhuman environment and that, as Davidson insists, most of our beliefs (most of *anybody's* beliefs) must be true. For this insistence gives us everything we wanted to get from 'realism' without invoking the slogan that 'the real and the true are "independent of our beliefs"'—a slogan which, Davidson rightly says, it is futile either to accept or to reject.

Davidson's claim that a truth theory for a natural language is nothing more or less than an empirical explanation of the causal relations which hold between features of the environment and the holding true of sentences, seems to me all the guarantee we need that we are, always and everywhere, 'in touch with the world'. If we have such a guarantee, then we have all the insurance we need against 'relativism' and 'arbitrariness'. For Davidson tells us that we can never be more arbitrary than the world lets us be. So even if there is no Way the World Is, even if there is no such thing as 'the intrinsic nature of reality', there are still causal pressures. These pressures will be described in different ways at different times and for different purposes, but they are pressures none the less.

The claim that ‘pragmatism is unable to account for the absoluteness of truth’ confuses two demands: the demand that we explain the relation between the world and our claims to have true beliefs and the specifically epistemological demand either for present certainty or for a path guaranteed to lead to certainty, if only in the infinitely distant future. The first demand is traditionally met by saying that our beliefs are made true by the world, and that they correspond to the way things are. Davidson denies both claims. He and Dewey agree that we should give up the idea that knowledge is an attempt to *represent* reality. Rather, we should view inquiry as a way of using reality. So the relation between our truth claims and the rest of the world is causal rather than representational. It causes us to hold beliefs, and we continue to hold the beliefs which prove to be reliable guides to getting what we want. Goodman is right to say that there is no one Way the World Is, and so no one way it is to be accurately represented. But there are lots of ways to act so as to realize human hopes of happiness. The attainment of such happiness is not something distinct from the attainment of justified belief; rather, the latter is a special case of the former.

Pragmatists realize that this way of thinking about knowledge and truth makes certainty unlikely. But they think that the quest for certainty—even as a long-term goal—is an attempt to escape from the world. So they interpret the usual hostile reactions to their treatment of truth as an expression of resentment, resentment at being deprived of something which earlier philosophers had mistakenly promised. Dewey urges that the quest for certainty be replaced with the demand for imagination—that philosophy should stop trying to provide reassurance and instead encourage what Emerson called ‘self-reliance’. To encourage self-reliance, in this sense, is to encourage the willingness to turn one’s back both on the past and on the attempt of ‘the classical philosophy of Europe’ to ground the past in the eternal. It is to attempt Emersonian self-creation on a communal scale. To say that one should replace knowledge by hope is to say much the same thing: that one should stop worrying about whether what one believes is well grounded and start worrying about whether one has been imaginative enough to think up interesting alternatives to one’s present beliefs. As West says, ‘For Emerson, the goal of activity is not simply domination, but also provocation; the telos of movement and flux is not solely mastery, but also stimulation.’

and

It may seem strange to say that there is no connection between justification and truth. This is because we are inclined to say that truth is the aim of inquiry. But I think we pragmatists must grasp the nettle and say that this claim is either empty or false. Inquiry and justification have lots of mutual aims, but they do not have an overarching aim called truth. Inquiry and justification are activities we language-users cannot help engaging in; we do not need a goal called ‘truth’ to help us do so, any more than our digestive organs need a goal called health to set them to work. Language-users can no more help justifying their beliefs and desires to one another than stomachs can help grinding up foodstuff. The agenda for our digestive organs is set by the particular foodstuffs being processed, and the agenda for our justifying activity is provided by the diverse beliefs and desires we encounter in our fellow language-users. There would only be a ‘higher’ aim of inquiry called ‘truth’ if there were such a thing as *ultimate* justification—justification before God, or before the tribunal of reason, as opposed to any merely finite human audience.

But, given a Darwinian picture of the world, there can be no such tribunal. For such a tribunal would have to envisage all the alternatives to a given belief, and know everything that was relevant to criticism of every such alternative. Such a tribunal would have to have what Putnam calls a ‘God’s eye view’—a view which took in not only every feature of the world as described in a given set of terms, but that feature under every other possible description as well. For if it did not, there would remain the possibility that it was as fallible as the tribunal which sat in judgment on Galileo, a tribunal which we condemn for having required justification of new beliefs in old terms. If Darwin is right, we can no more make sense of the idea of such a tribunal than we can make sense of the idea that biological evolution has an aim. Biological evolution produces ever new species, and cultural evolution produces ever new audiences, but there is no such thing as the species which evolution has in view, nor any such thing as the ‘aim of inquiry’.

To sum up, my reply to the claim that pragmatists confuse truth and justification is to turn this charge against those who make it. They are the ones who are confused, because they think of truth as something towards which we are moving, something we get closer to the more justification we have. By contrast, pragmatists think that there are a lot of detailed things to be said about justification to any given audience, but nothing to be said about justification in general. That is why there is nothing general to be said about the nature or limits of human knowledge, nor anything to be said about a connection between justification and truth. There is nothing to be said on the latter subject not because truth is atemporal and justification

temporal, but because *the only point in contrasting the true with the merely justified is to contrast a possible future with the actual present.*

I don't have to tell you that I find these ideas tremendously exciting. It is not that nature is hidden from us. It is that it is not all there yet and never will be; 'nature' is being hammered out as we speak. And just like with a good democracy, we all have a nonnegligible input into giving it shape. That is the idea I am testing for consistency and utility. On the chance that it will lead somewhere, it seems to me, worth the gamble.

2. TO H. M. WISEMAN, 27 JUNE 2002, "PROBABILISM ALL THE WAY UP"

Wisemanism 2 : *[Y]ou say that my language "builds about the ugliest picture it can for where this effort is going". As I keep saying, I mean to be provocative. I hope it drives you to new heights in building a beautiful picture in response. Honestly I do see the beauty in your program. And I think the more extreme it becomes, the more beautiful it becomes. I am very interested to see where it ends up.*

Thanks for the compliment. And, indeed, your correspondence does drive me to new heights (of something). But now I worry that I offended you with my phrase "ugliest picture." It probably came off that way, but it wasn't meant to be an emotional statement or a point about you personally. If some emotion did slip into it, it most likely refers to a conversation I had with Harvey Brown, circa September 11 of last year. Harvey kept saying that I wanted to "doom" nature to being "ineffable." But that language carries such a negative connotation. It carries the idea that there is something there that we can never, or should never, attempt to speak of. So, when you said something similar in print, it gave me the opportunity to try to reply in print. (As you know, I try to have my thoughts recorded so I can refer people to them. One of the original ideas was that it would save me time that way; so far, that aspect of it hasn't worked out.) Anyway, as I made clear, I want to combat that with all my strength. In particular, the way that I am thinking about it, it is not a bad thing that there are some things beyond description in nature. Instead, it is just a statement that there are more things to come; it is a way of leaving room for something new.

Wisemanism 3 : *[A]s it happens, I was reading a critique of Richard Rorty the very morning before I got your letter. Otherwise I never would have heard of him. It was a 1997 article by Alex Callinicos "Postmodernism: a critical diagnosis" [3]. The most interesting criticism in there was to say that Rorty "presumes what he needs to establish, namely that science and philosophy can be assimilated into literature. ... It is ... very hard in practice when trying to explain why one theory can be said to be more useful than another to avoid at least tacitly appealing to the idea that it captures how things are better than its rival does."*

Perhaps this is one aspect of Rorty you disagree with. But I wonder about your saying that quantum mechanics is the best justification for Rorty's philosophy, as if quantum mechanics is something you accept to be real, an "intrinsic nature of reality", the very idea of which Rorty explicitly rejects.

First, just a technical point. The philosophies I am most attracted to at present are those of James and Dewey and what James says about F. C. S. Schiller (but I haven't read Schiller himself yet). Rorty has donned himself to be the spokesman of those guys—and I don't mind that because he writes so nicely—but his writings also have a good admixture of the postmodernist ideas (of Foucault, Derrida, etc.) thrown into them to boot. This business about science not being more trustworthy or real than literary criticism presently strikes me as going too far.

But to Callinicos' point—"It is ... very hard in practice when trying to explain why one theory can be said to be more useful than another to avoid at least tacitly appealing to the idea that it captures how things are better than its rival does."—I would just reply, "Darwinism." And then, if that didn't sink in, I'd say, "Darwinism." The point is, from this conception, there is very little to say beyond that. Were elephants written into the blueprints of the universe? From the Darwinistic conception, they were not. Yet, the species fills a niche and has had a stability of at least a few million years worth. There is a sense in which an elephant, like a theory, is a "true" component in a description of the world. But that "trueness" only has a finite lifetime, and is largely a result of a conspiracy of things beyond its command (selection pressures). To put it another way, in contrast to Callinicos, the elephant doesn't "capture how things are better than its rival does" in any absolute sense—only in a transitory sense—but that doesn't take away from the functional value of the elephant today. So too, I am trying to imagine with theories.

Now, to quantum mechanics. You find something contradictory about my liking both quantum mechanics and Rorty. Here is the way I would put it. Presently at least, I am not inclined to accept quantum mechanics "to be real, an 'intrinsic nature of reality'," except insofar as, or to the extent that, it is a "law of thought," much like simple (Bayesian)

probability theory.² Instead, I view quantum mechanics to be the first *rigorous* hint we have that there might actually be something to James's vision.

I've already told you the history of this, haven't I? I gave a talk in 1999 at Cambridge on the quantum de Finetti theorem [4], after which Matthew Donald came up to me and bellowed, "You're an American pragmatist!" I didn't know what that meant really, but I kept the thought in the back of my head; I figured one day, I'd figure out what he meant. As it goes, that happened on July 21 of last year. I came across this book of Martin Gardner's of which one of the chapters was titled, "Why I Am Not a Pragmatist" [5]. (Part of the story is recorded on page 15 of my little samizdat in a note titled "The Reality of Wives" [6]. You might read it for a little laugh.) As I read it, it was like a flash of enlightenment. For every reason Gardner gave for not being a pragmatist, I thought about quantum mechanics and realized that indeed I was one. Donald was right after all; I am an American pragmatist. And my further study of pragmatism has borne that out to a T.

My point of departure, unlike James's, was not abstract philosophy. It was simply trying to make sense of quantum mechanics, where I think the most reasonable and simplest conclusion one can draw from the Kochen-Specker results [7] and the Bell inequality violations is, as Asher Peres says, "unperformed measurements have no outcomes" [9]. The measurement provokes the "truth value" into existence; it doesn't exist beforehand. Now, go off and read about James's and Dewey's theory of truth and you'll find almost exactly the same idea (just without the rigor of quantum mechanics). And similarly with lots of other pieces of the philosophy.

So, I view quantum mechanics as the hint of something much deeper. But the full story is not yet told. That is, quantum mechanics strikes me as being to our community what the Galapagos Islands were to Darwin—just a hint of something bigger.

Wisemanism 4 : *You and Rorty I guess would agree that "dreams of a final theory" will never be more than dreams. I guess that idea does not worry me as much as it would some physicists, but it does seem like a defeat. But perhaps that just says something of my personality. How much of a role does personality play in one's preferred philosophy?*

Your question is a good one and one I worry about a lot. Where your knee-jerk reaction is defeat, mine is one of unlimited possibilities and newfound freedom. On a similar issue, James put it like this:

The history of philosophy is to a great extent that of a certain clash of human temperaments. Undignified as such a treatment may seem to some of my colleagues, I shall have to take account of this clash and explain a good many of the divergencies of philosophies by it. Of whatever temperament a professional philosopher is, he tries, when philosophizing, to sink the fact of his temperament. Temperament is no conventionally recognized reason, so he urges impersonal reasons only for his conclusions. Yet his temperament really

² R. Schack and I made this point best, I believe, in the conclusion to our paper "Unknown Quantum States and Operations, a Bayesian View," quant-ph/0404156 [8]. Let me restate it here for clarity:

Is there something in nature even when there are no observers or agents about? At the practical level, it would seem hard to deny this, and neither of the authors wish to be viewed as doing so. The world persists without the observer—there is no doubt in either of our minds about that. But then, does that require that two of the most celebrated elements (namely, quantum states and operations) in quantum theory—our best, most all-encompassing scientific theory to date—must be viewed as objective, agent-independent constructs? There is no reason to do so, we say. In fact, we think there is everything to be gained from carefully delineating which part of the structure of quantum theory is about the world and which part is about the agent's interface with the world.

From this perspective, much—but *not all*—of quantum mechanics is about disciplined uncertainty accounting, just as is Bayesian probability theory in general. Bernardo and Smith write this of Bayesian theory,

What is the nature and scope of Bayesian Statistics ... ?

Bayesian Statistics offers a rationalist theory of personalistic beliefs in contexts of uncertainty, with the central aim of characterising how an individual should act in order to avoid certain kinds of undesirable behavioural inconsistencies. The theory establishes that expected utility maximization provides the basis for rational decision making and that Bayes' theorem provides the key to the ways in which beliefs should fit together in the light of changing evidence. The goal, in effect, is to establish rules and procedures for individuals concerned with disciplined uncertainty accounting. The theory is not descriptive, in the sense of claiming to model actual behaviour. Rather, it is prescriptive, in the sense of saying "if you wish to avoid the possibility of these undesirable consequences you must act in the following way.

In fact, one might go further and say of quantum theory, that in those cases where it is not just Bayesian probability theory full stop, it is a theory of stimulation and response. The agent, through the process of quantum measurement stimulates the world external to himself. The world, in return, stimulates a response in the agent that is quantified by a change in his beliefs—i.e., by a change from a prior to a posterior quantum state. Somewhere in the structure of those belief changes lies quantum theory's most direct statement about what we believe of the world as it is without agents.

gives him a stronger bias than any of his more strictly objective premises. It loads the evidence for him one way or the other, making a more sentimental or more hard-hearted view of the universe, just as this fact or that principle would. He *trusts* his temperament. Wanting a universe that suits it, he believes in any representation of the universe that does suit it. He feels men of opposite temper to be out of key with the world's character, and in his heart considers them incompetent and 'not in it,' in the philosophic business, even though they may far excel him in dialectical ability.

Yet in the forum he can make no claim, on the bare ground of his temperament, to superior discernment or authority. There arises thus a certain insincerity in our philosophic discussions: the potentest of all our premises is never mentioned. I am sure it would contribute to clearness if in these lectures we should break this rule and mention it, and I accordingly feel free to do so.

But I think the disparity between our views is in better shape than that. I think you're only seeing the program "physics is the ability to win a bet" as a defeat because—even if you don't know it—you're working within a kind of Kantian mindset. That the universe is already formed and there; that there is [a "thing in itself" in no way dependent upon us]. Anything that can't be said about the universe is then most surely a loss or limitation. But, I think once you see that what the pragmatist is trying to get at is not that, maybe your heart will change. Physics as the ability to win a bet will strike you as something immensely positive. Physics is like that because reality is still forming, and the Darwinistic component (along with the "non-detachedness" of the observer in quantum mechanics) indicates that it may be somewhat malleable. From that point of view, to have "dreams of a final theory" is almost like admitting defeat.

3. TO SEVERAL CORRESPONDENTS, 23 APRIL – 5 DECEMBER 2002, "SNOWFLAKES"

This morning, the family and I woke up to find some real snow coming down! It's wonderful. I'm just taken with it. A little while ago, in the middle of my writing the paragraph above, I explained to Emma the old childhood thing of how no two snowflakes are the same. That's a thought that has been capturing a lot of my attention lately: The world and the snowflake.

3.1. The POVM as a function from raw data to meaning

We generally write a POVM as an indexed set of operators, E_d . Here is how I would denote the referents of those symbols. The index d should be taken to stand for the raw data that can enter our attention when a quantum measurement is performed. The whole object E_d should be construed as the "meaning" we propose to ascribe to that piece of data when/if it comes to our attention. It is important here to recognize the logical distinction between these two roles. The symbol d stands for something beyond our control, something that enters into us from the world outside our head. The ascription of a particular value d is not up to us, by definition. The *function* E_d , however, is of a completely different flavor. It is set by our history, by our education, by whatever incidental factors that have led us to believe whatever it is that we believe when we walk into the laboratory to elicit some data. That is to say, E_d has much the character of a subjective probability assignment. It is a judgment.

I have tried to say this in various ways before. Maybe the first place in *Quantum States: W.H.A.T.?* [6] is in the note "Note on Terminology," pages 49–50, or in more detail in "Replies to a Conglomeration," page 92. Maybe there are still better shots at it, but I didn't look further. (I guess I also give another variation on the matter on page 42 of quant-ph/0205039 [10].) You can have a look at those if you think it'll help, but I think the paragraph above says it as well as anything.

3.2. POVMs and radical pluralism

Now let me go into a bit of the metaphysics of this. Here's a point of view that I'm finding myself more and more attracted to lately.

I think it is safe to say that the following idea is pretty commonplace in quantum mechanical practice. Suppose I measure a single POVM twice—maybe on the same system or two different systems, I don't care—and just happen

to get the same outcome in both cases. Namely, a single operator E_d . The common idea, and one I've held onto for years, is that there is an objective sense in which those two events are identical copies of each other. They are like identical atoms ... or something like the spacetime equivalent of atoms. But now I think we have no warrant to think that. Rather, I would say the two outcomes are identical only because we have (subjectively) chosen to ignore almost all of their structure.

That is to say, I now count myself not so far from the opinion of Ulfbeck and Bohr, when they write [11]:

The click ... is seen to be an event entirely beyond law. ... [I]t is a unique event that never repeats ... The uniqueness of the click, as an integral part of genuine fortuitousness, refers to the click in its entirety ... [T]he very occurrence of laws governing the clicks is contingent on a lowered resolution.

For though I have made a logical distinction between the role of the d 's and the E_d 's above, one should not forget the very theory-ladenness of the set of possible d 's to begin with. What I think is going on here is that it takes (a lot of) theory to get us to even recognize the raw data, much less ascribe it some meaning. In Marcus Appleby's terms, all that stuff resides in the "primitive theory" (or perhaps some extension of it), which is a level well below quantum mechanics. What quantum mechanics is about is a little froth on the top of a much deeper sea. Once that deeper sea is set, then it makes sense to make a distinction between the inside and the outside of the agent—i.e., the subjective and the objective—as we did above. For even in this froth on the top of a deeper sea, we still find things we cannot control once our basic beliefs—i.e., our theory—are set.

Without the potential d 's we could not even speak of the possibility of experiment. Yet like the cardinality of the set of colors in the rainbow—Newton said seven, Aristotle said three or four [14]—a subjective judgment had to be made (within the wide community) before we could get to that level. If this is so, then it should not strike us as so strange that the raw data d in our quantum mechanical experience will ultimately be ascribed with a meaning E_d that is subjectively given. (I expressed some of this a little better in a note I wrote to David [Mermin] last month; I'll place it below as a supplement.) All quantum measurements outcomes are unique and incomparable at the ontic level. At least that's the idea I'm toying with.

3.3. to N. D. Mermin, 25 September 2002, "Ulfbeck and Bohr"

I finally got a chance to read the Ulfbeck/Bohr paper [11]. I know I've complained about Niels Bohr's lack of detail when asserting the origin of the quantum formalism, but I think they force my complaints to a whole new level.

There is, however, one idea in the paper that I am inclined to keep or, at least to me, seems worth trying to develop. I say this predominantly because of its William Jamesian feel. Here it is, deleting the words of theirs that I don't like or don't agree with,

The click with its onset is seen to be an event entirely beyond law. ... [I]t is a unique event that never repeats ... The uniqueness of the click, as an integral part of genuine fortuitousness, refers to the click in its entirety, with all the complexity required for a break-through onto the spacetime scene. ... [T]he very occurrence of laws governing the clicks is contingent on a lowered resolution.

You see, from the Jamesian viewpoint of "radical pluralism," every piece of the universe, every crumb of its existence, is a unique entity unto itself. Here's a little quote in that direction from his essay "Abstractionism and 'Relativismus'" [12]:

Let me give the name of 'vicious abstractionism' to a way of using concepts which may be thus described: We conceive a concrete situation by singling out some salient or important feature in it, and classing it under that; then, instead of adding to its previous characters all the positive consequences which the new way of conceiving it may bring, we proceed to use our concept privatively; reducing the originally rich phenomenon to the naked suggestions of that name abstractly taken, treating it as a case of 'nothing but' that concept, and acting as if all the other characters from out of which the concept is abstracted were expunged. Abstraction, functioning in this way, becomes a means of arrest far more than a means of advance in thought. It mutilates things; it creates difficulties and finds impossibilities; and more than half the trouble that metaphysicians and logicians give themselves over the paradoxes and dialectic puzzles of the universe may, I am convinced, be traced to this relatively simple source. *The viciously privative employment of abstract characters and class names* is, I am persuaded, one of the great original sins of the rationalistic mind.

I wish I could find a better quote than that—I have memories of reading the idea expressed in much greater detail and so much more eloquently—but this morning, try as I might, I can’t find it.

So I’ll end this little note with another note I wrote a few months ago to Greg Comer—it carries the sentiment, if not the eloquence. It’s pasted below. Maybe I should have titled the present email, “A Click Is But a Click Not: It Is So Much More.” For the same holds with “clicks” as with “atoms.”

3.4. to G. L. Comer, 23 April 2002, “Music in the Musician”

I think we just have to get rid of this imagery that we are “made” of atoms. Or none of us are ever going to make any progress in our emotional lives *or* our physical understanding. By my present thinking, a much better imagery is this. Take me and an old log: we both float in water. That is to say, we have that much in common. But there are a heck of a lot more things that we do not have in common. For any two entities, we can always find some characteristics they have in common, if *we* are willing to ignore all the ways in which they are distinct. And that, I think, is the story of atoms. The atomic picture has something to do with what we all have in common. (Or, maybe more potently, it has something to do with what is common in the *part* of existence that we have chosen not to ignore for the moment.) But to see the atomic picture shine through, we have to dim down all the things that are unique in us. Who said the particular shape of that rock is not important? Who said the pain you are feeling is only epiphenomena?

Such a picture of what physics and chemistry is about is every bit as consistent as the worldview Steven Weinberg [15], say, would have us believe. And I would say that it is more so; for it gives us a power and a hope for control in our lives that his can’t imagine.

4. TO N. D. MERMIN AND R. SCHACK, 12 AUGUST 2003, “ME, ME, ME”

Me, me, me; it’s always about me! —Yes. But nonetheless it is simply not solipsism. Let me explain.

I guess I was actually fortunate today: For the second time in a month, I was called a solipsist by one of my friends. (This time the accuser was Howard Wiseman.) On top of that, Asher Peres gave a talk this morning that made me cringe, saying things like, “When no one performs a measurement, nothing happens [in the world].” The combination of these two bad experiences caused me to wander the streets of Aarhus this afternoon in spite of the horrible heat. I suppose I needed to find a way to sweat the poisons from my body.

The fortune in this is that it caused me once again to strive for a clearer and more consistent form of expression. I want to try to capture some of that in this note. Mostly it is about not allowing oneself to get hung up in someone else’s (inconsistent) expectations for what quantum theory ought to be.

In our 2000 opinion piece in *Physics Today* [13], Asher and I wrote:

The thread common to all the nonstandard “interpretations” is the desire to create a new theory with features that correspond to some reality independent of our potential experiments. But, trying to fulfill a classical worldview by encumbering quantum mechanics with hidden variables, multiple worlds, consistency rules, or spontaneous collapse, without any improvement in its predictive power, only gives the illusion of a better understanding. Contrary to those desires, quantum theory does *not* describe physical reality. What it does is provide an algorithm for computing *probabilities* for the macroscopic events (“detector clicks”) that are the consequences of our experimental interventions. This strict definition of the scope of quantum theory is the only interpretation ever needed, whether by experimenters or theorists.

But that is misleading and trouble-making. In the second to last sentence—with the experience of three more years of thinking on this subject—I so wish we had said something more to the tune:

What quantum theory does is provide a framework for structuring MY expectations for the consequences of MY interventions upon the external world.

At least that is what the formal structure is about. There is no “we,” there is no “our.” At this level of consideration, quantum theory has nothing to do with intersubjective agreement. (By the way, I’m not fooling myself: Of course we could not have said what I said above without restructuring the whole article—it would have opened a can of worms! I just want to try to do the idea better justice right now.)

Here it is: Any single application of quantum *theory* is about ME, only me. It is about MY interventions, MY expectations for their consequences, and MY reevaluations of MY old expectations in the light of those consequences. It is noncommittal beyond that. This is not solipsism; it is simply a statement of the subject matter.

Is there any contradiction in this? I say no, but how do I get you into a mindset so that you might say the same? Maybe the best way to do this is to run through a glossary of quantum terms as I did once before . . . but now with all the latest slant.

- **SYSTEM:** In talking about quantum measurement, I divide the world into two parts—the part that is subject to (or an extension of) my will, and the part that is beyond my control (at least in some aspects). The idea of a “system” pertains to a part beyond my control. It counts as the source of my surprises, and in that sense obtains an existence of its own external to me. (Point #1 against solipsism, but I will return for another.)
- **POVM:** In the theory, this counts as an extension of my will. It counts as a freely chosen action on my part. The whole concept of a “measuring device” as something distinct from me—I am now thinking—just gets in the way. It is a point that Pauli made, but I am coming ever more to appreciate it. A “measuring device” is like a prosthetic hand; its conceptual role is for the purpose of recovering from our natural incapacities and, thus, might as well be thought of as part of ourselves proper. I perform a POVM on a system—captured mathematically by a set—and one of its elements comes about as a consequence.
- **QUANTUM STATE:** As usual, the catalog of MY expectations for the consequences of MY actions (i.e., POVMs) . . . but now with absolute, utter emphasis on the MY.
- **UNITARY READJUSTMENT:** I’m talking here about the readjustment appearing in Eq. (95) of my paper quant-ph/0205039 [10]. This, like a quantum state, also captures a belief or expectation. Its purpose is to quantify the extent to which I feel the need to deviate from Bayes’ rule after learning the consequence of my action. This is what takes account of the nonpassive nature of MY interventions.
- **QUANTUM DYNAMICS:** This is the unitary readjustment (or mixture of decompositions and unitary readjustments) that I judge I ought to apply if my action on the system is passive, i.e., if my POVM is the singleton set. It is how I readjust my expectations when I am learning nothing.

Summing up the glossary, I would say quantum theory in its single user implementation is about ME. I act on the world and it reacts in a way unpredictable to me beyond the expectations I build from MY quantum state (about the system).

Why is this not solipsism? Because quantum theory is not a theory of everything. It is not a statement of all that is and all that happens; it is not a mirror image of nature. It is about me and the little part I play in the world, as gambled upon from my perspective.³ But just as I can use quantum theory for my purposes, you can use it for yours. Thus, if I had not been seeking dramatic effect above, I should have more properly said, “Any single application of quantum *theory* is about the ME who applies it.” (Don’t correct my English.) When David Mermin is a practitioner of quantum theory, what the theory does is provide a framework for structuring HIS expectations for the consequences of HIS interventions upon HIS external world. . . . And that is Point #2 against solipsism.

Recall the definition of solipsism I dredged up from the *Encyclopedia Britannica*:

in philosophy . . . the extreme form of subjective idealism that denies that the human mind has any valid ground for believing in the existence of anything but itself.

It seems to me we have plenty of valid ground for believing in the existence of something besides ourselves: It comes from all the things we cannot control. Indeed, as already emphasized, for those things we can control, we might as well think of them as extensions of ourselves. Thus, to my mind, quantum theory already gives a karate chop to solipsism because of the indeterminism it entails: With each quantum measurement there is immediately something beyond my control.

Beyond Point #1, though, there is Point #2. It is a question of finally getting straight what should and should not be in the purview of the theory. In this account, quantum theory is a theory of personal action (and reaction). The law-of-thought aspect of it comes out with respect to each individual who uses it. The textbook poses an exercise that

³ See footnote 2.

starts out, “Suppose a hydrogen atom is in its ground state. Calculate the expectation of ... blah, blah, blah.” One might think it is asking us to calculate some objective feature of the world. It is not. It is only asking us to carry out the logical consequences of a supposed state of belief and a supposed action that one could take upon the system. And here’s the clincher about Bayesianism. Just as no student in his right mind would find it worthy to ask why the textbook writer posed the problem with the ground state rather than the first excited state, no quantum theorist should make a big to-do about it either. It is simply an assumed starting point. An agent in the thick middle of a quantum application can no more ask where he got his initial beliefs from, than a pendulum can ask where it got its initial conditions from. The cause of bottom-level initial conditions is *always* left unanalyzed. If such was not a sin in Newtonian mechanics, it should not be a sin in a Bayesian formulation of quantum mechanics.

So, it seems to me, if anything, the Bayesian account of quantum theory is essentially the opposite of solipsism. Rather than a unity to nature, it suggests a plurality. An image that might be useful (but certainly flawed) comes from Escher’s various paintings of impossible objects. The viewer would initially like to think of them as two-D projections of a three-dimensional object; but he cannot. Now imagine how much worse it would get if we were to have two viewers with two slightly different paintings, each purporting to be a different perspective on “the” impossible object. Since neither viewer can lift from his own two-D object to a three-D one, there is no way to unify the pictures into a single whole.

Yet we live in one world, you say. Maybe. But, you should remember that these quantum states we speak of are not perspectives. They are personal possessions. To modify Tilgher’s quote at the beginning of de Finetti’s “Probabilismo” [16] for our own purposes,

A quantum state is not a mirror in which a reality external to us is faithfully reflected; it is simply a biological function, a means of orientation in life, of preserving and enriching it, of enabling and facilitating action, of taking account of reality and dominating it.

“Are there other minds beside your own?,” Howard Wiseman asks. If a mind is what it takes to write down a quantum state, then why not? “If you leave the origin of the quantum state unanalyzed, why would two minds ever agree on anything?” That is the issue of intersubjective agreement—something thankfully we can study within the context of quantum theory. But the first thing to get straight is why the single user of quantum theory uses the very structure. What is it precisely that he is believing of the world and his place in it that leads him to the choice of quantum theory as his law of thought?

That is, it is about ME and what I believe. But what do I believe? That’s the research program!

5. TO A. SUDBERY AND H. BARNUM, 18 AUGUST 2003, “THE BIG IF”

I have been trying to give Mr. Nagel a concerted effort during my vacation here in Munich. I went out and bought *The View from Nowhere* [17] and am a little way into it.

It’s probably too early in my reading to tell, but my troubles with Nagel may all boil down to “The Big IF.” That is, they may boil down to the religion that lies behind this passage plucked out of his article “Subjective and Objective.” (I’ll capitalize the big IF and a couple of other appropriate words so that you’ll know what I’m talking about.) Here goes:

Since a kind of intersubjective agreement characterizes even what is most subjective, the transition to a more objective viewpoint is not accomplished merely through intersubjective agreement. Nor does it proceed by an increase of imaginative scope that provides access to many subjective points of view other than one’s own. Its essential character, in all the examples cited, is externality or DETACHMENT. The attempt is made to view the world not from a place within it, or from the vantage point of a special type of life and awareness, but from nowhere in particular and no form of life in particular at all. The object is to discount for the features of our pre-reflective outlook that make things appear to us as they do, and thereby to reach an understanding of things as they really are. We flee the subjective under the pressure of an assumption that everything must be something not to any point of view, but in itself. To grasp this by DETACHING more and more from our own point of view is the unreachable ideal at which the pursuit of objectivity aims.

Some version of this polarity can be found in relation to most subject matter—ethical, epistemological, metaphysical. The relative subjectivity or objectivity of different appearances is a matter of degree, but the same pressures toward a more external viewpoint are to be found everywhere. It is recognized that one’s own point of view can be distorted as a result of contingencies of one’s makeup or situation. To compensate

for these distortions it is necessary either to reduce dependence on those forms of perception or judgment in which they are most marked, or to analyze the mechanisms of distortion and discount for them explicitly. The subjective comes to be defined by contrast with this development of objectivity.

Problems arise because the same individual is the occupant of both viewpoints. In trying to understand and discount for the distorting influences of his specific nature he must rely on certain aspects of his nature which he deems less prone to such influence. He examines himself and his interactions with the world, using a specially selected part of himself for the purpose. That part may subsequently be scrutinized in turn, and there may be no end to the process. But obviously the selection of trustworthy subparts presents a problem.

The selection of what to rely on is based partly on the idea that the less an appearance depends on contingencies of this particular self, the more it is capable of being arrived at from a variety of points of view. IF THERE IS A WAY THINGS REALLY ARE, which explains their diverse appearances to differently constituted and situated observers, then it is most accurately apprehended by methods not specific to particular types of observers. That is why scientific measurement interposes between us and the world instruments whose interactions with the world are of a kind that could be detected by a creature not sharing the human senses. Objectivity requires not only a departure from one's individual viewpoint, but also, so far as possible, departure from a specifically human or even mammalian viewpoint. The idea is that if one can still maintain some view when one relies less and less on what is specific to one's position or form, it will be truer to reality. The respects in which the results of various viewpoints are incompatible with each other represent distortions of the way matters really are. And if there is such a thing as the correct view, it is certainly not going to be the unedited view from wherever one happens to be in the world. It must be a view that includes oneself, with all one's contingencies of constitution and circumstance, among the things viewed, without according it any special centrality. And it must accord the same DETACHED treatment to the type of which one is an instance. The true view of things can no more be the way they naturally appear to human beings than the way they look from here.

The pursuit of objectivity therefore involves a transcendence of the self, in two ways: a transcendence of particularity and a transcendence of one's type. It must be distinguished from a different kind of transcendence by which one enters imaginatively into other subjective points of view, and tries to see how things appear from other specific standpoints. Objective transcendence aims at a representation of what is external to each specific point of view: what is there or what is of value in itself, rather than *for* anyone. Though it employs whatever point of view is available as the representational vehicle—humans typically use visual diagrams and notation in thinking about physics—the aim is to represent how things are, not *for* anyone or any type of being. And the enterprise assumes that what is represented is DETACHABLE from the mode of representation, so that the same laws of physics could be represented by creatures sharing none of our sensory modalities.

The two key ideas in this passage that I think quantum mechanics plays the most havoc with are:

1. the DETACHED agent (observer, scientist, etc.), and
2. IF THERE IS A WAY THINGS REALLY ARE ...

I honestly believe one can take the Nagel worldview seriously—I suspect there is no logical flaw in it. One can legitimately try to make quantum mechanics fit that worldview with more or less success. My only point is the strong personal suspicion that with such a project one forces quantum mechanics into shoes it does not fit. And, as I see it, what bunions that will cause in the future!

The whole subject matter of my *Notes on a Paulian Idea* [19] is in toying with the idea that the cleanest expression of quantum mechanics will come about once one realizes that its overwhelming message is that the observer cannot be detached from the phenomena he *helps* bring about. I italicize the word *helps* because I want you to take it seriously; the world is not solely a social construction, or at least I cannot imagine it so. For my own part, I imagine the world as a seething orgy of creation. It was in that orgy before there were any agents to practice quantum mechanics and will be in the same orgy long after the Bush administration wipes the planet clean. Both of you have probably heard me joke of my view as the “sexual interpretation of quantum mechanics.” There is no one way the world is because the world is still in creation, still being hammered out. It is still in birth and always will be—that's the idea. What quantum mechanics is about—I toy with—is each agent's little part in the creation (as gambled upon from his own

perspective).⁴ It is a theory about a very small part of the world. In fact, I see it as a theory that is trying to tell us that there is much, much more to the world than it can say. I hear it pleading, “Please don’t try to view me as a theory of everything; you take away my creative power, my very promise, when you do that! I am only a little theory of how to gamble in the light of a far more interesting world! Don’t shut your eyes to it.”

The question is, how to get one’s head around this idea and make it precise? And then, once it is precise, what new, wonderful, wild conclusions can we draw from it? That is the research program I am trying to define.

Is it a *scientific* research program? I think so, and in the usual sense. There will be lemmas, theorems, and corollaries. (I would like to think that my work and the work of the fellows I’ve drawn down this path already evidences this.) Ultimately there will be calls for experiments. There will be technologies suggested and money to be made from the program’s fruits. Failure of nerve? Anything but!:

Sudberyism 1 : *Maybe you and [Rorty] can shift me from my instinctive reaction to pragmatism, which is that for a scientist it represents a failure of nerve, a failure of imagination, and most seriously a failure of curiosity. Being useful cannot, for a scientist, be the end of the story about a statement or a theory; we immediately want to know why one theory is more useful than another. That “why?” leads us to an external world of some kind, maybe very strange (the stranger the better, i.e. the more interesting, I would say) and to refuse to follow where it leads seems to me to be a scientific copout.*

I see it as anything but a failure of curiosity or a copout! What you wrote me above reminds me of a conversation I had with Chris Timpson in a pub one night. I made the mistake of mentioning William James, and Chris quickly intoned, “All James was about was the nonsense that truth resides in what is useful.” The word *all* just boomed! A man’s whole life was dismissed in a single sentence. I cut him short, “William James was about many things, *one of which* was that the correspondence theory of truth holds no water.” Similarly I will say to you, there is far more explored by the pragmatist thinkers than that which is delimited by their ideas on truth and warranted belief. Pragmatism is not positivism; it is not that there is nothing to be sought in science beyond the connections between sense perceptions. I see the classical pragmatists (and myself) as ultimately realists, but honest realists—ones who have realized that our theories are not mirror images of the underlying reality, but rather extensions of our biological brains.

But that is going in a direction I don’t want to go down at the moment. In any case, don’t read Rorty first! Read James’ little book *Pragmatism* [18] to start off with. More immediately, with respect to the present Nagelian discussion, read (in my *Notes on a Paulian Idea* [19]) “Genesis and the Quantum” on pages 122–123, the dialogue between Adam and God on pages 118–120, “Evolution and Physics” and “Precision” on pages 267–270, and some of Jeff Bub’s expressions on the idea in Chapter 9, most notably pages 139–140 and 141–142—all these things in the samizdat I sent you. The game of *assuming* the possibility of a detached observer, as Nagel does, is just that: a game of assuming. Thereafter, Nagel tries to make sense of our more personal worlds in spite of this. The pages I’ve just referred to in my samizdat try to sketch what quantum mechanics might be talking about if one does not make such an assumption. In fact, they try to justify *not* making the assumption at all. I hope from these readings you will get the impression that though there may be a fundamental disagreement between Nagel and me at the outset, such a disagreement does not necessarily amount to a copout on my part.

6. TO H. MABUCHI, 17 JUNE 2004, “PREAMBLE”

I think I would like you to also post the little text file below along with my other suggested readings for my “Intro to QM” lecture. You can give it the title “Preamble”. It was something I sketched out on my flight over here, and reading over it again, I kind of like it.

A lecturer faces a dilemma when teaching a course at a farsighted summer school like this one. This is because, when it comes to research, there is often a fine line between what one thinks and what is demonstrable fact. More than that, conveying to the students what one thinks—in other words, one’s hopes, one’s desires, the potentest of one’s premises—can be just as empowering to the students’ research lives (even if the ideas are not quite right) as the bare tabulation of any amount of demonstrable fact. So I want

⁴ See footnote 2.

to use one percent of this lecture to tell you what I think—the potentest of all my premises—and use the remaining ninety-nine to tell you about the mathematical structure from which that premise arises.

I think the greatest lesson quantum theory holds for us is that when two pieces of the world come together, they give birth. [Bring two fists together and then open them to imply an explosion.] They give birth to FACTS in a way not so unlike the romantic notion of parenthood: that a child is more than the sum total of her parents, an entity unto herself with untold potential for reshaping the world. Add a new piece to a puzzle—not to its beginning or end or edges, but somewhere deep in its middle—and all the extant pieces must be rejiggled or recut to make a new, but different, whole. That is the great lesson.

But quantum mechanics is only a glimpse into this profound feature of nature; it is only a part of the story. For its focus is exclusively upon a very special case of this phenomenon: The case where one piece of the world is a highly-developed decision-making agent—an experimentalist—and the other piece is some fraction of the world that captures his attention or interest.

When an experimentalist reaches out and touches a quantum system—the process usually called quantum ‘measurement’—that process gives rise to a birth. It gives rise to a little act of creation. And it is how those births or acts of creation impact the agent’s *expectations* for other such births that is the subject matter of quantum theory. That is to say, quantum theory is a calculus for aiding us in our decisions and adjusting our expectations in a QUANTUM WORLD. Ultimately, as physicists, it is the quantum world for which we would like to say as much as we can, but that is not our starting point. Quantum theory rests at a level higher than that.

To put it starkly, quantum theory is just the start of our adventure. The quantum world is still ahead of us. So let us learn about quantum theory.

7. TO G. MUSSER, 7 JULY 2004, “THE BIG BANG IS ALL AROUND US”

Musserism 1 : *[Fuchs said,] “It is a theory about a very small part of the world... a theory that is trying to tell us that there is much, much more to the world than it can say.” How is this not hidden variables?*

Sure, they may not be hidden variables in the pre-existing sense – i.e. in the sense that a properly designed experiment can come asymptotically close to ascertaining their pre-experiment value. But does not “more to the world” imply something hidden?

Take a break from me for a moment and ask yourself how the Everett interpretation is not a hidden-variable theory? (It almost seems you would have asked the Everettian the same thing you asked me.) A hidden-variable theory is a very specific thing: If one were to know the value (even if only hypothetically and not operationally) of all the variables (including possibly the ones on the inside of the observer), then one can predict the outcome of all measurements with certainty. It is a fancy way of saying measurement outcomes pre-exist, even if nothing one would ever call a measurement is actually performed.

The determination or setting of specific measurement outcomes (in any quantum mechanical experiment) has always been outside of the quantum mechanical formalism. There is nothing in the formalism that determines whether one will get this click or whether one will get that click in some measurement device. But that does not make it a hidden-variable theory. What is hidden?

Here is the way Pauli put it [20]:

Like an ultimate fact without any cause, the individual outcome of a measurement is, however, in general not comprehended by laws. This must necessarily be the case ...

In the new pattern of thought we do not assume any longer the detached observer, occurring in the idealizations of this classical type of theory, but an observer who by his indeterminable effects creates a new situation, theoretically described as a new state of the observed system. In this way every observation is a singling out of a particular factual result, here and now, from the theoretical possibilities, thereby making obvious the discontinuous aspect of the physical phenomena.

Nevertheless, there remains still in the new kind of theory an objective reality, inasmuch as these theories deny any possibility for the observer to influence the results of a measurement, once the experimental arrangement is chosen.

(The conjunction of these thoughts is what I call “the Paulian idea”—hence the name of my book [19].) “Like an ultimate fact without any cause, the individual outcome of a measurement is not comprehended by laws.”

The way I see it, quantum measurement outcomes are ultimate facts without specific call for further explanation. And indeed the quantum formalism supplies none. Thus there is more to the world than the quantum formalism can supply. Nothing to do with hidden variables.

But more specifically, regarding your point:

Musserism 2 : *“It is a theory about a very small part of the world... a theory that is trying to tell us that there is much, much more to the world than it can say.” How is this not hidden variables?*

How does the theory tell us that there is much more to the world than it can say? It tells us that *facts* can be made to come into existence, and not just at some time in the remote past called the “big bang” but here and now, all the time, whenever an observer sets out to perform (in antiquated language) a quantum measurement. I find that fantastic! And it hints that facts are being created all the time all around us. But that now steps out of the domain of what the quantum formalism is about, and so is the subject of future research. At the present—as a first step—I want rather to make the interpretation of the quantum formalism along these lines absolutely airtight. And then from there we’ll better know how to go further.

Doesn’t that just make you tingle? That (metaphorically, or maybe not so metaphorically) the big bang is, in part, right here all around us? And that the actions we take are *part* of that creation! At least for me, it makes my life count in a way that I didn’t dare dream before I stumbled upon Wheeler, Pauli, and Bell-Kochen-Specker.

But let me get away from this speculation and rope myself back in on your particular question: How is this not some hidden variables account? Simple: If there are any extra facts being created around us, they nevertheless do not impinge on the individual quantum measurement outcome.

When I say that QM is a theory about a very small part of the world, you should literally think of a map of the United States in relation to the rest of the globe. The map of the US is certainly incomplete in the sense that it is obviously not a map of the whole globe. But on the other hand it is as complete as it can be (by definition) as a representation of the US. There are no hidden variables that one can add to the US map that will magically turn into a map of the whole globe after all. The US map is what it is and need be nothing more.

Does that help any?

I think a good bit of the problem comes from something that was beat into most of us at an early age. It is this idea: Whatever else it is, quantum theory should be construed as a theory of the world. The formalism and the terms within the formalism somehow reflect what is out there in the world. Thus, if there is more to the world than quantum theory holds out for, the theory must be incomplete. And we should seek to find what will complete it.

But my tack has been to say that that is a false image or a false expectation. Quantum theory from my view is not so much a law of nature (as the usual view takes), but rather a law of thought. In a slogan: Quantum mechanics is a law of thought. It is a way of plagiarizing George Boole who called probability theory a law of thought. (Look at the first couple of entries in the Rüdiger Schack chapter of *Notes on a Paulian Idea* [19].) Try to think of it in these terms, and let’s see if this helps.

Let us take a simple term from probability theory, namely a probability distribution over some hypothesis $P(h)$. This function represents a gambling agent’s expectations about which value of h will obtain in an observation or experiment. Suppose now the agent gathers a separate piece of data d from some other observation or experiment and uses it to conditionalize his expectations for h ; i.e., he readjusts his expectations for h to some new function $P(h|d)$ by using Bayes’ rule. Now here’s a question for you. Is there anything within abstract probability theory that will allow the agent to predict precisely which value of d he will find when he gathers his data? Of course not. It’s almost silly to pose the question. Abstract probability theory has nothing to do with the actual facts of the world. But then, doesn’t that mean that probability theory is an incomplete theory? It can’t, for instance, explain its own transitions $P(h) \longrightarrow P(h|d)$ since probability theory alone can’t tell us why this d rather than that d . Moreover if probability is incomplete in this way, shouldn’t we be striving to complete it? Both silly questions, and I hope for obvious reasons.

So:

1. There is no particular mystery in the transition $P(h) \longrightarrow P(h|d)$.
2. We would never expect probability theory to provide a mechanism to determine which value of d is found or produced in the experiment. The value d represents a fact of the world, and probability theory is *only* a theory about how to manipulate expectations once facts are given.
3. But also no one would be compelled to call probability theory incomplete because of this.
4. In particular, admitting this does not amount to having a hidden-variable explanation of probability theory.

So I say with quantum mechanics. The story is almost one-to-one the same: You just replace probability distributions with quantum states. ... But then you reply, “But there’s a difference; quantum theory is a theory of physics, it is not simply a calculus of thought.” And I say, “That’s where you err.” Quantum theory retains a trace of something about the real, physical world but predominantly it is a law of thought that agents should use when navigating in the (real, physical) world. In particular, just like with probability theory, we should not think of quantum theory as incomplete in the usual sense. If it is incomplete in any way, it is only incomplete in the way that the US map is incomplete with respect to the globe: There’s a lot more land and ocean out there.

“Teasing out” (your words) the trace of the physical world in the formalism—i.e., the part of the theory that compels the rest of it as a useful law of thought—is the only way I see to get a solid handle on what quantum mechanics is trying to tell us about nature itself.

With this let me now go back to the US map for one final analogy. I said that there is a sense in which the US map is as complete as it can be. However there is also a sense in which it tells us something about the wider world: If we tabulate the distances between cities, we can’t help but notice that the map is probably best drawn on the surface of a globe. I.e., the US already reveals a good guess on the curvature of the world as a whole—it hints that the world is not flat. And that’s a great addition to our knowledge! For it tells a would-be Columbus that he can safely go out and explore new territories. Exploring those new territories won’t make the US map any more complete, but it still means that there is a great adventure in front of him.

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